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Original Article

The Prevalence and Pattern of Hearing Impairment in Children with Epilepsy

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ABSTRACT

Background: In developed countries, hearing impairment is ten times more common in children with epilepsy (CWE) compared to the general population. Hearing impairment and epilepsy may exist in the same individual due to shared aetiology, recurrent seizures or use of antiepileptic drugs. This comorbidity may impact CWE's quality of life. **Aim:** This study aimed to determine the prevalence, pattern and predictors of hearing impairment among CWE in North-Central Nigeria to increase awareness and encourage early screening and intervention. **Methods:** A cross-sectional comparative study was carried out at the Jos University Teaching Hospital on children with epilepsy and their apparently healthy age and sex-matched counterparts. Hearing assessment was performed using pure tone audiometry, free field audiometry, and otoacoustic emission. **Results:** The prevalence of hearing impairment among the children with epilepsy was 24% compared to 7% among the controls (x^2= 11.03, p = 0.001). The severity of hearing impairment was mild, moderate, severe, and profound in five (5.0%), twelve (12.0%), three (3.0%), and four (4.0%) of the 100 CWE. No severe or profound hearing impairment cases were found in the control group. There was no statistically significant association between factors such as age group, age at onset of seizure, age at first presentation, school history, severity of seizures, intracranial infection, use of anti-epileptic drugs (AED) and hearing impairment in CWE. **Conclusion:** Hearing impairment is more common among children with epilepsy compared to their age and sex-matched controls. Screening for hearing impairment should be done as part of the initial assessment of CWE.

Keywords: Prevalence, Pattern, Hearing impairment, Epilepsy, Children

INTRODUCTION

Hearing impairment in children with epilepsy may result from shared aetiology, recurrent seizures or use of antiseizure medications. Lance *et al*[1] reported a case of a school-age child with hearing impairment, absence seizure and ADHD with poor school performance, while Cross *et al*[2] described a cohort with East syndrome (epilepsy, ataxia, sensorineural hearing loss and tubulopathy syndrome) who had tonic-clonic seizures in infancy. In another case report, 5 out of 6 siblings in a family were found to have variable combinations of hearing impairment, epilepsy and other abnormalities.[3] In developing countries, perinatal asphyxia and central nervous infections are prominent risk factors for epilepsy and hearing impairment as a long-term sequela.[4-7] Hearing impairment is an important sequela of acute bilirubin encephalopathy

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(ABE), and some children who had ABE later develop epilepsy. [8-9]

Hearing impairment may also arise due to the seizure disorder and/or its treatment.[10-13] Excessive electrical discharges in children with epilepsy may alter the auditory pathway's anatomical and functional integrity, leading to impaired processing of auditory stimuli and hearing impairment. Anti-epileptic drugs have also been shown to be associated with delayed conduction within the cochlear, auditory nerve and brainstem auditory pathways, resulting in both auditory and peripheral vestibular dysfunction.[12,14] Common implicated drugs include carbamazepine, phenytoin, valproate, lamotrigine, gabapentin, vigabatrin and oxcarbazepine, even at their therapeutic doses.[11]

In the USA, hearing impairment is ten times more common in children with epilepsy than in the general population (22% vs. 2%).[15] There are no comparative studies on hearing impairment and epilepsy in Nigeria. This study aimed to determine the prevalence, pattern, and predictors of hearing impairment among Children with epilepsy (CWE) and their age and sex-matched controls in North-Central Nigeria.

MATERIALS AND METHODS

This was a cross-sectional comparative study to describe the prevalence, pattern and predictors of hearing impairment in children with epilepsy at the Jos University Teaching Hospital (JUTH) and their apparently healthy age and sex-matched counterparts. Cases were children aged 15 months to 18 years of age with a confirmed diagnosis of epilepsy defined according to the International League Against Epilepsy.[16]

Controls were apparently healthy children matched for age and sex with cases who had no epilepsy or other chronic disorders. Those with other chronic diseases, such as cardiac, renal, and sickle cell disease, and those with symptoms and signs of acute illness were excluded from the study.

Sample Size Determination:

The sample size was determined to detect a difference of 20% in the prevalence of neurological conditions between children with epilepsy and controls using the formula for comparing two proportions. The standard normal deviation corresponding to a 5% level of significance (2-sided) was 1.96, and the standard normal deviation corresponding to a power of 80% was 0.84. The proportion with neurological conditions in the Epilepsy group was 68.3%, representing the highest frequency of paediatric neurological disorders in a tertiary hospital in Sagamu. This gave a minimum of 91 subjects in each group, rounded up to 100 to cater for non-responses. Therefore, a total of 100 children with epilepsy and 100 age and sex-matched apparently healthy controls were studied.

One hundred consecutive eligible patients presenting at the Paediatric Neurology Clinic were recruited as cases until the sample size was attained. One hundred age and sex-matched eligible peers were recruited from the classes of the patients' schools (for those in school) and the communities where they live (for those not in school).

Consent for the study was obtained after educating the parents/ caregivers about the study.

A designed proforma was used to obtain the sociodemographic data (using the Oyedeji [17] classification) and treatment history, including the type and number of antiepileptic drugs, dosage, duration, and compliance with treatment. Past medical history was reviewed for any suspected risk factors for epilepsy. Schooling history included when the subjects enrolled, current attendance, whether they were in their appropriate classes, and whether they had repeated classes.

Hearing Assessment

Depending on age, the hearing assessment was performed using pure tone audiometry, free field audiometry (FFA), and otoacoustic emission (OAE). All the hearing assessments were conducted in the Audiology Room of the Ear Nose and Throat Department of Jos University Teaching Hospital.

Otoacoustic emission was used to assess those below two years of age because it does not require behavioural responses.[18] Subjects with at least three tick responses were regarded as having normal hearing, while those having two or fewer were regarded as having impaired hearing. Free field/Play audiometry (FFA) was used to assess subjects aged two to five years. Hearing was classified as normal (10 -25db), mild hearing impairment (26 - 40dB), moderate hearing impairment (41 – 60dB), severe hearing impairment (61 – 80dB) and profound hearing impairment (>80dB)[19]

Pure tone audiometry was used to assess hearing in children aged > over 5. Each ear was tested at a time, and the hearing level when the child last perceived a sound at a particular frequency was recorded on the audiogram in decibels (dB). All the results were recorded on an audiogram, and hearing was classified as FFA.

Data Analysis

STATA IC 14.2 by Stata Corp LLC, Texas, USA, for Macintosh Operating Systems was used to analyse the data.

Continuous variables were presented in median with interquartile range, while categorical variables were presented as proportions. Comparison between continuous variables was made using the

student's t-test, while those between categorical variables were done using the Chi-square test and Fisher's exact test. The associations between seizure variables, demographic characteristics and presence or absence of hearing impairment were tested using the Chi-square test. The level of significance was set at p< 0.05

Approval for this study was obtained from the Ethical Committee of the Jos University Teaching Hospital.

RESULTS

One hundred children with epilepsy aged between 15 months and 18 years were compared with 100 apparently healthy controls. They comprised of 55 males and 45 females in each group (M: F 1.2:1). The sociodemographic characteristics of the study population are described in Table I.

Twenty-four (24%) of the CWE had hearing impairment compared to seven (7%) of the controls, and the difference was statistically significant (χ^2 11.03, p= 0.001), as shown in Table IV.

Those below two years and with profound intellectual disability had normal hearing as assessed by OAE. The severity of hearing impairment was mild, moderate, severe, and profound in 5 (5.0%), 12 (12.0%), 3 (3.0%) and 4 (4.0%) of the 100 CWE. Of the seven children in the control group with hearing impairment, 3 (3.0%) had mild hearing impairment, while 4 (4.0%) had moderate impairment. No cases of severe or profound hearing impairment were found in the control group. The pattern of hearing impairment found among CWE, and their age and sex-matched controls is shown in Fig 1.

As shown in Table V, there was no statistically significant association between factors such as age group, age at onset of seizure, age at first presentation, school history, severity of seizures, intracranial infection, use of AED, and hearing impairment in CWE.

Because there was no statistically significant association between sociodemographic and clinical variables with hearing impairment, logistic regression analysis was not done to determine independent predictors of hearing impairment.

Table I: Sociodemographic Characteristics of the Study Population.

Characteristics	CWE, n=100 Freq (%)	Controls, n=100 Freq (%)	χ^2	df	P value
Age groups (years)			0.12	2	0.93
1-5	31 (31.0)	29 (29.0)			
>5-10	31 (31.0)	33 (33.0)			
>10	38 (38.0)	38 (38.0)			
Median age (IQR) years	8 (4-13)	9 (5-13)	4827*		0.67
Gender			0.00	1	1.00
Male	55 (55.0)	55 (55.0)			
Female	45 (45.0)	45 (45.0)			
Socioeconomic class			3.26**	4	0.51
I	12 (12.0)	9 (9.0)			
II	21 (21.0)	32 (32.0)			
III	33 (33.0)	30 (30.0)			
IV	33 (33.0)	28 (28.0)			
V	1 (1.0)	1 (1.0)			

CWE= Children with Epilepsy; * Mann-Whitney U test; ** Fishers Exact test.

The median (IQR) age at first epileptic seizure and age at presentation were 3 (1 - 7) years and 5 (2-10) years, respectively. There was a significant difference between the median age at onset and the median age at presentation (x^2=93.282, p<0.001). The median seizure duration before diagnosis was 6 (1-24) months. Seventy (70%) CWE had generalised epilepsy, while sixty-four (64%) of cases had severe epilepsy defined as a seizure frequency of at least one seizure attack per month; a history of status seizures was obtained in 48(48%) (Table II).

The mean duration of treatment was 2.6± 0.5 months; 32 (32%) were on AED monotherapy, while 68 (68%) were on polytherapy (Table III).

DISCUSSION

The prevalence of hearing impairment obtained in this study was higher among CWE than controls. This is in contrast to the findings of Burton *et al*[20] in a

community-based study in Tanzania, where the prevalence of hearing impairment was higher among the control group (0% Vs 0.9%). The difference may be due to the method of hearing assessment used. Burton *et al*[20] assessed hearing by auditory discrimination from three meters behind the subject.

discrimination. Lagunju *et al*[7] observed that hearing impairment was among the least additional neurologic impairment among CWE in UCH Ibadan, but the prevalence and methods used for assessing hearing impairment in the study were not stated. However, Mung'ala- Odera *et al*[21] in Kenya and Ogunlesi *et al*[6]

Table II. Clinical Characteristics of 100 Children with Epilepsy

Characteristic	Frequency	Percentage
Age at first epileptic seizure		
<1year	21	21.0
1-5years	45	45.0
6-10years	27	27.0
>10years	7	7.0
Median (IQR) - 3 (1 - 7) years		
Age at first	10	10.0
presentation	47	47.0
<1year	27	27.0
1-5years	16	16.0
6-10years		
>10years		
The median (IQR) - 5 (2-10) years		
Duration before epilepsy diagnosis		
<1year	59	59.0
1-5years	34	34.0
6-10years	05	05.0
>10years	02	02.0
Type of seizure		
Generalized seizure (n =70)	70	70.0
Generalised tonic clonic	44	44.0
Childhood absence seizure	07	7.0
Atonic	06	6.0
Mixed	06	6.0
Generalised tonic	03	3.0
Generalised clonic	02	2.0
Myoclonic	02	2.0
Focal seizure (n = 30)	30	30.0
Focal impaired awareness	20	20.0
Focal to bilateral tonic clonic seizure	07	7.0
Focal aware seizure	03	3.0
Severity of seizure		
Severe	64	64.0
Not severe	36	36.0
History of Status epilepticus		
Yes	48	48.0
No	52	52.0

Some persons with mild to moderate hearing impairment may do well with auditory discrimination and might be missed unless an objective assessment is done. In this study, hearing assessment was done using audiometry and otoacoustic emission, which have higher specificity and sensitivity than auditory

in Sagamu, Nigeria, found a prevalence of hearing impairment of 18% and 18.6%, respectively, among CWE similar to what was obtained in this study. This may have been because similar methods of auditory assessments were employed.

Table III. Pattern of Antiepileptic drug use among 100 children with epilepsy

Current Antiepileptic drugs	Frequency	Percentage
Carbamazepine	80	80.0
Sodium valproate	44	44.0
Phenobarbitone	13	13.0
Ethosuximide	5	5.0
Levetiracetam	1	1.0
Others	2	2.0
Polytherapy	68	68.0
Monotherapy	32	32.0
Mean treatment duration	2.6± 0.5 months	

Table IV. Prevalence of Hearing impairment in CWE and controls.

Hearing impairment	CWE Freq (%)	Controls Freq (%)	X^2	P value
Present	24 (24.0)	7 (7.0)	11.03	**0.001**
Absent	76 (76.0)	93 (93.0)		

Fisher's Exact Test.

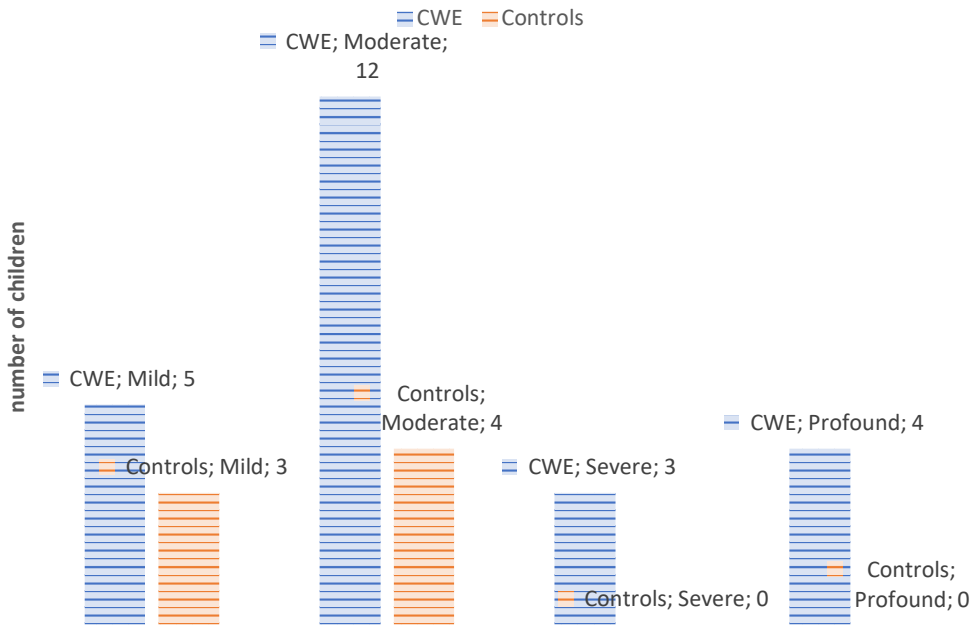

Figure 1. The pattern of hearing impairment in CWE compared to controls

The prevalence of hearing impairment among apparently healthy controls in this study was similar to the findings of Khairi *et al*[22] in a meta-analysis, which found that as much as 2.4-14.9% of apparently healthy individuals have hearing impairments mainly due to preventable risk factors.

The severe form of hearing impairment seen among the CWE but not among the controls could be explained by the fact that risk factors such as intracranial infections, perinatal asphyxia and neonatal jaundice known to cause both hearing impairment and epilepsy were prevalent among the CWE.[4-9] However, these risk factors were not screened for in this study for appropriate comparison

None of the patient's characteristics evaluated in this study reached a statistically significant association with hearing impairment. Although the age at the onset of seizures had a trend towards statistical significance, it did not reach the value for the study. The literature on the association between hearing impairment and epilepsy is quite scarce. There are few case reports of various syndromes with coexisting hearing impairment and epilepsy. [23-24] Even though Ogunlesi[13] and Mung'ala–Odera[21] also reported an

Table V. Factors Associated with Hearing Impairment in 100 Children with Epilepsy.

Factor	Hearing impairment	No hearing impairment	□2	P value
Age group, years			**3.79***	**0.289**
<1	0 (0.0)	1 (100.0)		
1-5	7 (22.6)	24 (77.4)		
6-10	11 (35.5)	20 (64.5)		
>10	6 (16.2)	31 (83.8)		
Age at onset of seizure, years			**6.78***	**0.068**
<1	5 (23.8)	16 (76.2)		
1-5	15 (33.3)	30 (66.7)		
6-10	2 (7.4)	25 (92.6)		
>10	2 (28.6)	5 (71.4)		
Age at first presentation, years			**2.93***	**0.395**
<1				
1-5	2 (20.0)	8 (80.0)		
6-10	15 (31.9)	32 (68.1)		
>10	4 (14.8)	23 (85.2)		
AED Therapy	3 (18.7)	13 (81.3)		
Polytherapy			**0.439**	**0.508**
Monotherapy	9 (28.1)	23 (71.9)		
	15 (22.1)	53 (77.9)		
Status epilepticus				
Yes			**2.660**	**0.103**
No	15 (31.3)	33 (68.8)		
Schooling history	9 (17.3)	43 (82.7)		
(Children □5yrs)			**2.290***	**0.853**
Appropriate	10 (23.8)	32 (76.2)		
Repeat	5 (33.3)	10 (66.7)		
Dropout	0 (0.0)	3 (100.0)		
Not enrolled	4 (33.3)	8 (66.7)		
Special school	0 (0.0)	1 (100.0)		
Severity of seizure			**0.09**	**0.755**
Present	16 (25.0)	48 (75.0)		
Absent	8 (22.2)	28 (77.8)		
Intracranial infection			**0.27**	**0.602**
Present	6 (28.6)	15 (71.4)		
Absent	18 (23.1)	60 (76.9)		
Carbamazepine			**0.21***	**0.640**
Present	20 (25.0)	60 (75.0)		
Absent	4 (20.0)	16 (80.0)		
Sodium valproate			**0.04**	**0.836**
Present	11 (25.0)	23 (75.0)		
Absent	13 (23.2)	43 (76.8)		
Ethosuximide			**0.04***	**0.830**
Present	1 (20.0)	4 (80.0)		
Absent	23 (24.2)	72 (75.8)		

increased prevalence of hearing impairment in their subjects with epilepsy, none of them tested the association between patients' characteristics and hearing impairment.

In conclusion, the prevalence of hearing impairment is higher among CWE than their age and sex-matched controls. Severe and profound types of hearing impairment were found in CWE but not in the controls. There was no statistically significant difference between sociodemographic and clinical variables and hearing impairment; as such, no independent predictor of hearing impairment was determined. CWE should be assessed for hearing impairment as part of their initial evaluation.

Limitations

The study, being cross-sectional, cannot accurately predict factors that may suggest hearing impairment among children with epilepsy. Also, this study has not differentiated common aetiopathology factors common to epilepsy and hearing impairment from aetiopathologic factors that may cause one but not the other.

Strengths of the study: The study has demonstrated that the prevalence of hearing impairment is high among children with epilepsy. It has highlighted an area that is usually not a common concern among them.

CONCLUSION

The prevalence of hearing impairment among CWE is significantly higher than that of the general children population.

Policy Implications

Hearing assessment should be done for children with epilepsy, especially in this environment where the common risk factors for epilepsy and hearing impairment are still prevalent.

Need for future research: A further study comparing children with epilepsy who have a hearing impairment and children with epilepsy without hearing impairment may highlight better factors associated with hearing impairment.

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The authors declare no conflict of interest.

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